Chapter 10

Polymers

Day – 1

Polymers

Introduction

The word 'polymer' is coined from two Greek words: *poly* means many and *mer* means unit or part. The term polymer is defined as very large molecules having high molecular mass (103-107u). These are also referred to as macromolecules, which are formed by joining of repeating structural units on a large scale. The repeating structural units are derived from some simple and reactive molecules known as monomers and are linked to each other by covalent bonds. This process of formation of polymers from respective monomers is called polymerization.

Classification of Polymers

1:- Classification Based on Source

a) ***Natural Polymers:-*** These polymers are found in plants and animals. Examples are proteins, cellulose, starch, resins and rubber.

b) ***Semi-synthetic Polymers:-*** Cellulose derivatives as cellulose acetate (rayon) and cellulose nitrate, etc. are the usual examples of this sub category.

c) ***Synthetic Polymers:-*** A variety of synthetic polymers as plastic (polythene), synthetic fibres (nylon 6,6) and synthetic rubbers (Buna - S) are examples of manmade polymers extensively used in daily life as well as in industry.

2:- Classification Based on Structure of Polymers

d) ***Linear Polymers:-*** These polymers consist of long and straight chains. The examples are high density polythene, polyvinyl chloride.

e) ***Branched chain Polymers:-*** These polymers contain linear chains having some branches, *e.g.*, low density polythene.

f) ***Cross linked or Network Polymers:-*** These are usually formed from bi-functional and tri-functional monomers and contain strong covalent bonds between various linear polymer chains, e.g. Bakelite, melamine.

3:- Classification Based on Mode of Polymerisation

g) ***Addition Polymers:-*** The addition polymers are formed by the repeated addition of monomer molecules possessing double or triple bonds, *e.g.*, the formation of polythene from ethene and polypropene from propene.

h) ***Condensation Polymers:-*** The condensation polymers are formed by repeated condensation reaction between two different bi-functional or tri-functional monomeric

units. In these polymerisation reactions, the elimination of small molecules such as water, alcohol, hydrogen chloride, etc. take place. The examples are terylene (Dacron), nylon 66, nylon 6.

4:- Classification Based on Monomers

i) ***Homopolymers****:- the addition polymers formed by the polymerisation of a single monomeric species are known as homopolymers, e.g., polythene.*

j) ***Copolymers:-*** The polymers made by addition polymerisation from two different monomers are termed as **copolymers**, *e.g.*, Buna-S, Buna-N.

5:- Classification Based on Molecular Forces

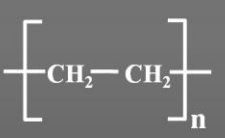
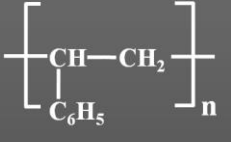
k) ***Elastomers:-*** These are rubber – like solids with elastic properties. In these elastomeric polymers, the polymer chains are held together by the weakest intermolecular forces. These weak binding forces permit the polymer to be stretched. A few 'crosslink's' are introduced in between the chains, which help the polymer to retract to its original position after the force is released as in vulcanised rubber. The examples are Buna-S, Buna-N, neoprene, etc.

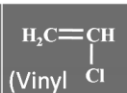
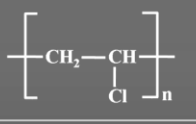
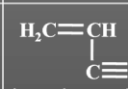
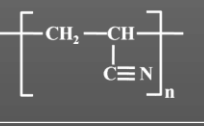
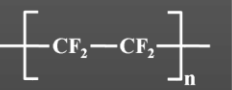
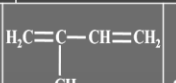
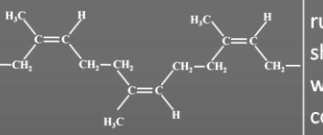
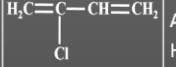
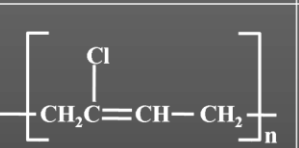
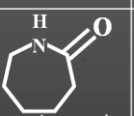
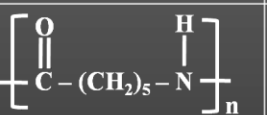
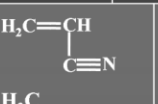
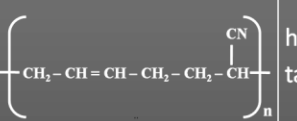
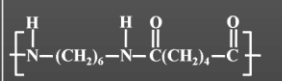
l) ***Fibres:-*** Are the thread forming solids which possess high tensile strength and high modulus. These characteristics can be attributed to the strong intermolecular forces like hydrogen bonding. These strong forces also lead to close packing of chains and thus impart crystalline nature. The examples are polyamides (nylon 6, 6), polyesters (Terylene), etc.

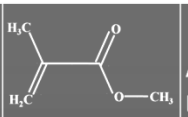
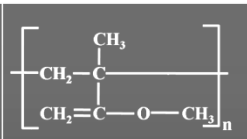
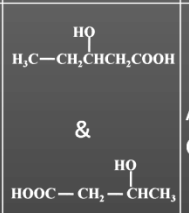
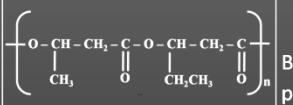
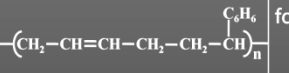
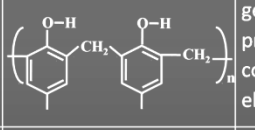
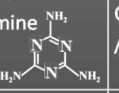
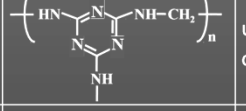
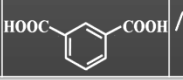
m) ***Thermoplastic Polymers:-*** These are the linear or slightly branched long chain molecules capable of repeatedly softening on heating and hardening on cooling. These polymers possess intermolecular forces of attraction intermediate between Elastomers and fibres. Some common thermoplastics are polythene, polystyrene, polyvinyl, etc.

n) ***Thermosetting Polymers:-*** These polymers are cross linked or heavily branched molecules, which on heating undergo extensive cross linking in moulds and again become infusible. These cannot be reused. Some common examples are Bakelite, urea-formaldehyde resins, etc.

<u>Some Important Polymers and their monomers/Types/Uses/structure</u>

Polymer	Monomer	Type	Polymer Structure	Uses
Poly-ethene	$H_2C{=}CH_2$ (ethene)	Addition/ Homopolymer		Insulator, packaging, household and laboratory wares
Poly-styrene	$C_6H_5CH{=}CH_2$ (styrene)or(ethenylbenzene) or (phenylethene)	Addition/ Homopolymer		Insulator, toys, household articles, packaging etc.

Polyvinyl chloride (PVC)	 (Vinyl Chloride)	Addition/ Homopolymer		Sheets, flooring, hand bags, raincoats etc.
Poly-acrylonitrile (PAN or Orlon)	 (acrylonitrile)	Addition/ Homopolymer		Synthetic fiber and wool
Polytetrafloroethene (PTFE or Teflon)	 (tetrafloroethene)	Addition/ Homopolymer		Insulators, gaskets, lubricants etc. Non-stick utensils
Natural Rubber	 2-methylbutadiene (isoprene)	Addition/ Homopolymer		Vulcanized rubber in shoes, waterproof coats, car tyres etc.
Neoprene	 (Chloroprene)	Addition/ Homopolymer		Insulator, conveyor belts, printing rollers et.
Nylon 6	 (Caprolactum)	Condensation /Homopolymer		Fibers, plastics, rope etc.
Nitrile Rubber BUNA-N	 (acryonitrile) and(1,3-butadiene)	Addition/ Copolymer		hoses and tank linings
Nylon 66	$HOOC(CH_2)_4COOH$ (adipic acid) and(hexamethylene diamine) $H_2N\text{-}(CH_2)_6\text{-}NH_2$	Condensation/ Copolymer		brushes, parachutes, carpets etc.

Polymethyl metha acrylate (PMMA) Plexiglass	 Methylmethacrylate	Addition/ Homopolymer		Sheets used in place of glass
PHVB β→ polyhydroxy butrate –Co– β- hydroxy butrate		Addition/ Copolymer		Biodegrable palymer
Styrene butadiene rubber BUNA-S	(1,3-butadiene)  and Styrene C_6H_5-CH=CH_2	Addition/ Copolymer		tyres and footwear
Urea formaldehyde	(formaldehyde) HCHO and (urea)NH_2CONH_2	Addition/ Copolymer		unbreakable cups and laminated sheets
Bakelite	(Formaldehyde)HCHO and (Phenol)C_6H_5OH	Condensation / Copolymer		gears, protective coatings, electrical fittings
Melamine-formaldehyde	HCHO and Melamine 	Condensation / Copolymer		unbreakable crockery
Glyptal	$HOCH_2$-CH_2OH and phthalic acid 	Condensation / Copolymer		paints and lacquers